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Five Years Later: Children's Memory for Medical Emergencies

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SUMMARY

Children who had been 2–13 years of age at the time of a medical emergency (an injury serious enough to require hospital ER treatment) were re-interviewed about their injury and treatment five years after injury, and three years after a previous interview. The children showed excellent recall of the central components of their injury experience, although their recall of hospital treatment was more incomplete. Thus, both the nature of the event being recalled (the injury versus the hospital treatment) and the centrality of information (central versus peripheral) were important. The recall of 2-year-olds, although not as good as that of children just a year older, did not fit with predictions of infantile amnesia since they recalled a considerable amount about their injury. High stress levels at the time of the target experiences had little effect on the highly memorable injury event, but seemed to facilitate children's recall of central components of the hospital event—the event that they had a harder time remembering. Implications for eyewitness testimony are discussed. Copyright © 2001 John Wiley & Sons, Ltd.

This study is a 5-year follow-up of children who had been injured seriously enough to require hospital emergency-room treatment. Very little research has investigated such long delays in children's memory, and yet there is increasing incidence of children being asked to give eyewitness testimony about events long after those events have occurred. At times, the delays between event occurrence and court appearance extend over a period of years (Gray, 1993). Thus, investigation of children's long-term memory has both theoretical and practical implications.

A few studies have assessed children's memory after long periods of time have elapsed (Gold and Neisser, 1980; Hudson and Fivush, 1991; Pillemer *et al.*, 1994; Quas *et al.*, 1999; Sheingold and Tenney, 1982). For example, Hudson and Fivush (1991) asked children to recall a kindergarten field trip to a museum six years later, and they found that recall was very limited unless photographs of the trip (taken at the time) were given to the children as prompts. What was recalled, however, tended to be accurate. Pillemer *et al.* (1994) asked children to recall the details surrounding a fire alarm and school evacuation

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that had taken place in their preschool seven years previously. They found that children who were under 4 years of age at the time recalled little whereas children over 4 years had better recall, although still far from complete.

Quas *et al.* (1999) suggest that the nature of the events being recalled may play a key role in long-term memory, and specifically that emotional events may be retained in memory much better and for longer periods of time. Indeed, there is a long history of research with adults showing that emotional events are remembered far better and for longer (e.g. Christianson, 1992; Rapaport, 1942) while less salient events are more readily forgotten. In fact, laboratory research has routinely found strong decrements in memory as a function of time delays when recall involves items that are not personally salient. The studies of children's very long-term memory cited above mostly asked children to recall events with little personal relevance or salience. Thus, there is a need for studies of children's memory for emotional events after long periods of time have passed. Such studies are rare although much needed (Quas *et al.*, 1999). Most of that research has involved extreme life-threatening trauma and has been anecdotal in nature (Howe, 1997; Terr, 1988).

Recently, Quas *et al.* (1999) explored children's long-term memory for a painful medical procedure, a VCUG (voiding cystourethrogram fluoroscopy), dividing children into age groups of under versus over 4 years of age, and experiencing short (under 36 months) versus long (over 36 months) delays between the procedure and subsequent questioning. They found that younger children were unlikely to even recall having had a VCUG, especially the 2-year-olds who had either no memory at all or only a vague memory of the event, whereas older children mostly recalled the event. Unfortunately, there were only two younger children with long delays between the VCUG and subsequent recall so it is difficult to extrapolate how long delays and age interact.

The importance of age in determining whether or not children recall a particular event over a long period of time has been especially important when exploring the phenomenon of infantile amnesia. Research on adults' earliest memories suggest that most adults fail to recall events that occurred prior to the age of 3 or 4 (McCabe *et al.*, 1991; Mullen, 1994; Pillemer and White, 1989; Sheingold and Tenney, 1982), although the content of those experiences may play a role (Usher and Neisser, 1993). Yet, children who are preschoolers often recall events that happened when they were much younger, and even 1- and 2-year-olds show explicit memory for events that had occurred 6 months earlier (Bauer and Wewerka, 1995; Fivush *et al.*, 1987, 1995; Hamond and Fivush, 1991). As well, both 2- and 3-year-olds have demonstrated considerable recall of medical emergencies after delays of up to 2 years (Peterson, 1999; Peterson and Rideout, 1998). However, a number of investigators have suggested that once a long enough delay has ensued, events that were formerly accessible to memory are no longer recalled (Fivush *et al.*, 1987; Goodman *et al.*, 1991; Pillemer, 1992; Pillemer *et al.*, 1994). Thus, it is important to explore the recall of children after the passage of several years who had been only 2 or 3 years of age at the time of event occurrence. In the present study, such children are interviewed 5 years after the target events had occurred. Investigations of the memory of such young children have important implications for the debate about infantile amnesia.

There are other factors that may well play an important role in influencing children's long-term recall. One such factor is the nature of the various information details that are to be recalled. In particular, considerable research has suggested that details that are perceived as central rather than peripheral are recalled much better and for longer periods of time (Christianson, 1992). Indeed, when children were asked to recall the details of medical events after a delay of a few days, weeks or months, central details were predictably recalled better than peripheral details (Goodman *et al.*, 1991; Peterson and Bell, 1996). However, an exploration of how information centrality affects memory after much longer time delays is needed.

As well, the nature of the event being recalled may also play a role. Even when the event is stress-arousing or painful, there may be differences depending upon the nature of that event. Most of the investigations of children's recall of stressful events has focused on procedures that occurred within doctors' or dentists' offices or medical procedures that took place in hospitals (e.g. Burgwyn-Bailes *et al.*, 2001; Goodman *et al.*, 1991; Quas *et al.*, 1999; Steward *et al.*, 1996; Vandermaas *et al.*, 1993). Such procedures have included minor plastic surgery, VCUGs, inoculations and venipuncture as well as suturing and bone-casting. In all of these procedures, children have the details of what will happen explained to them both before and during the procedures. Such explanation and discussion may well play a role in how memorable the events are. Indeed, preparation by parents prior to a VCUG improved children's subsequent recall (Goodman *et al.*, 1997), and as well, children who asked more questions during the course of a medical procedure also recalled more (Baker-Ward *et al.*, 1995). From such research it could be inferred that children are more likely to recall events for which there is preparation and discussion while the target events are occurring than for other events where there has been no such preparation. However, children have been shown to have better recall for accidental injuries, for which there was obviously no prior discussion, than for subsequent medical treatment which was discussed before it was done (Peterson, 1999; Peterson and Bell, 1996). In the present study, children's recall of injury details will be compared with hospital details, to see how the event being recalled affects long-term memory.

There is one more factor that will be investigated, namely the degree of distress experienced by the children at the time of the target events. The injuries were mostly painful and distressing, but the degree of distress exhibited by different children varied. Some children were absolutely hysterical and parents described them as being more distressed than they had ever previously seen them, while other children were considerably less distressed (Peterson and Bell, 1996). Investigations of how stress interacts with memory have found mixed results, with some studies showing higher stress to be associated with both better (e.g. Goodman *et al.*, 1991) and worse (e.g. Bruck *et al.*, 1995; Merritt *et al.*, 1994) recall, while others have shown mixed or no significant effects of stress on memory (Eisen *et al.*, 1998; Peterson and Bell, 1996; Vandermaas *et al.*, 1993). In a study of children's recall of a VCUG after the passage of years, Quas *et al.* (1999) found that children who had been more highly stressed reported less information in response to free recall or anatomical doll and prop questions, while they were simultaneously less likely to be misled. The authors account for these results not by suggesting that higher stress led to children recalling less about the events, but that more highly distressed children were less willing to talk about the target events.

In the present study, children who had previously been recruited from a hospital ER after suffering injuries requiring treatment were tracked down 5 years later. Although these children had previously been interviewed about their experiences multiple times, namely after 1 week, 6 months, 1 year and 2 years, they had not been contacted during the preceding 3 years. Furthermore, the 5-year contact was unexpected. The children ranged from 2 to 13 years of age at the time of injury and thus were between 7 and 18 at the time of the follow-up interviews. Our hypotheses are as follows: We expect the five-year delay between event occurrence and interview (and the three-year delay between the prior interview and the present one) to lead to a considerable decrement in children's recall, at least for peripheral details. We also expect age to be an important variable influencing children's long-term recall, with older children recalling more. The long-term recall of children who had been only 2 years of age at the time of injury is especially interesting theoretically. Although these children still recalled the target events after the passage of two years (Peterson, 1999), others have suggested that events recalled over relatively short periods of time are unlikely to be recalled after the passage of several years. However, Usher and Neisser (1993) found that the experience of hospitalization was sufficiently memorable that even the majority of their college-aged participants recalled such events occurring when they were only 2 years of age, although other sorts of events were not recalled until age 3 or 4. Thus, we expect some recall of the target events by former 2-year-olds. In terms of event identity, we expect that injury details will be recalled better than hospital treatment details, parallel to previous research (Peterson, 1999; Peterson and Bell, 1996). We make no prediction about whether or not stress will affect long-term recall since prior research has been so mixed about this variable.

METHOD

Participants

The children in this study had been recruited from the emergency room of the only children's hospital in Newfoundland, Canada. All children within a 100-mile radius are taken exclusively to this emergency room for treatment, and thus the children (mostly White) represent a cross-section of the community in terms of socioeconomic status. They had experienced trauma injuries that were treated in an outpatient manner, including lacerations requiring suturing, bone fractures, second-degree burns, dog bites, and crushed fingers requiring drainage.

There were 81 children (38 girls and 43 boys) who participated in the 5-year follow-up study. For simplicity, especially when comparing initial recall with 5-year follow-ups, children will always be referred to according to the age they were at the time of injury, not the age they were at the 5-year interview. The long-term memory of 2-year-olds was of particular interest because of infantile amnesia, and as well, their memory performance was considerably different from that of all other ages of children, including 3-year-olds, in all previous interviews of these children (Peterson, 1999; Peterson and Bell, 1996). Thus, 2-year-olds constitute a separate age group in all analyses, while there is some grouping of older children. The age groups were as follows: nine 2-year-olds (mean age = 2.7, range = 2.2–2.11, seventeen 3–4-year-olds (mean age = 3.10, range = 3.0–4.11, seventeen 5–6-year-olds (mean age = 5.10, range = 5.1–6.11), twenty-two 8–9-year-olds (mean age = 8.10, range = 8.2–9.11) and sixteen 12–13-year-olds (mean age = 12.7, range = 12.0–13.6).

Procedure

When initially recruited, the families of all children had been approached in the hospital emergency room where they were asked to participate in a study of children's long-term memory. Approximately 85% of families agreed to participate. They were then contacted at home by phone and a home visit set up a few days later. At this time the children were interviewed about what they recalled of their injuries and subsequent treatment; parents and if necessary, other adult witnesses such as relatives, babysitters and teachers were also interviewed in order to provide a standard against which to evaluate the accuracy and completeness of the children's information. Children were always interviewed first, with the standardized interview described below. The same standardized interview was given to parents and other witnesses. In addition, parents and other witnesses who knew the child well were asked to rate the children's degree of distress at both the time of injury and the time of hospital treatment. The rating scale ranged from '1—not upset, not distressed at all' to '6—extremely upset, highly distressed'.

The first interview took place a few days after the injury (mean delay = 7.3 days). Subsequently, children were interviewed 6 months later (mean delay = 6 months 3 days), 1 year later (mean delay = 12 months 2 days), 2 years later (mean delay = 24 months 6 days), and finally 5 years later (mean delay = 5 years, 3 months). The 2- and 5-year interviews were unexpected by the families. At all the interviews except the first one, parents were asked to not discuss the target event with their child prior to the arrival of the interviewer because we were interested in what the children themselves remembered. Parents almost universally reported at our visits 6 months, 1 year, and 2 years post-injury that the target events had not been mentioned for several months previously because they were 'old news'. In fact, at the 1-, 2-, and 5-year interviews most parents claimed that the last discussion of the events had been when the children had been previously interviewed. Only the data from the 5-year interviews as well as the initial interviews for comparison are presented here. For information about the 6-month interview, see Peterson and Bell (1996), and for information about recall at 1 and 2 years post-injury, see Peterson (1999).

The format of each interview was the same: free recall was first ('Tell me about when you hurt yourself. What happened?' 'Tell me about when you went to the hospital. What happened?'). At later interviews, the children were reminded of their injuries ('Remember that time you broke your arm? Tell me about it. What happened?'). After free recall, they were given probes using wh- questions ('Where were you when it happened? Who was with you? What did you do when you first got hurt?'). If children provided information about a specific element in free recall, they were not subsequently asked about it in probed recall. Every effort was made to avoid yes-no questions, since the reliability of responses to such questions is suspect (Fay, 1975; Peterson and Biggs, 1997; Peterson *et al.*, 1999). Data from the few yes–no questions that were asked are ignored. The questionnaire itself was the same for each interview regardless of time delay or whether the interview was of the child or the parent. The interviews were audio-recorded and subsequently transcribed verbatim. In situations in which the child responded nonverbally to a question (e.g. 'How many stitches did you get?' and the child held up three fingers), the interviewer stated the child's response for the tape recorder ('You are holding up three fingers') and this was counted as the child's providing a content response. All scoring was done from the transcripts.

Scoring of recall data

Even though all the children experienced a personally unique injury and hospital treatment, they all accommodate a prototypical pattern that included various components from both the injury and hospital events. Most prototype items included in the scoring were applicable to all children (e.g. place where injury occurred, who brought them to the hospital), while others applied only to a subset of children, e.g. getting a cast, having a needle). Which prototype items applied to each child were determined from inspecting the parent transcripts. Because of this variation in how many prototype elements applied to their individual situations, different children had different numbers of scorable items that were relevant to them and thus could potentially be present in their recall of each of the two events (injury and hospital treatment). All prototype items were classified as pertaining to the injury or hospital treatment. As well, all items were classified as central or peripheral. In the present study, we define central versus peripheral details according to Heuer and Reisberg's (1992) distinction of plot relevant versus plot-irrelevant information, respectively. This is the same definition as was used to distinguish central from peripheral details in Peterson and Bell (1996), although there, peripheral details were additionally subdivided into two categories. Here, both categories of peripheral details are combined. The prototype classification and examples of each item are shown in the Appendix.

After determining which components of the prototype applied to each child, the child's transcripts were searched to determine, first, whether the child supplied information relevant to each prototype component in each interview. If such information was provided, it was then compared with the information provided by adult witnesses in order to assess accuracy. The coding of 'accurate' was given not only for complete agreement between child and adult responses but also for close approximations. For example, if the child said that she had been injured when she was 'in a restaurant' and her parent said they had been 'in McDonald's', the child was credited with making an accurate response. Children who misstated the number of stitches or X-rays were not credited with an error if they correctly said that they had received stitches or X-rays. In rare cases children provided information which was not commented on by witnesses; in these cases the data were excluded from the analysis. To establish reliability, two raters scored 17% of the transcripts, and agreement averaged 96.6%.

The following sets of data were analysed:

(1) The *completeness* of children's recall of relevant components was determined, that is, the proportion of relevant event components that were recalled. This score was directed toward answering the question 'How much of what happened did children actually remember?' (Only components that were accurately recalled were included here.) This proportion of recalled relevant components is presented separately for the injury and hospital-treatment events, and for central versus peripheral details. The completeness of a child's recall was calculated by dividing the number of component items of each type that were correctly recalled by the number of component items that were relevant for that child according to parent report and thus that could potentially have been recalled.

(2) The *accuracy* of the children's recall was determined. In this analysis, only commission errors were counted, that is, instances in which a child stated information that was explicitly contradicted by the adult witness's report. The numbers of commission errors about prototype components were counted for each of the episodes of injury and treatment events separately, as well as for central versus peripheral details. Then, the percentage accuracy of the actual prototype components that had been provided by the children was calculated. Instead of using the possible components that children potentially could have remembered as the denominator in calculations (as in the first measure described above), the actual components that children did provide was used as the denominator in calculations, and the proportion

of those components that were accurate was determined. That is, the number of correct prototype components of each type was divided by the total number of relevant components the child provided (i.e. the sum of correct plus incorrect components).

RESULTS

Analyses of completeness scores

First, the completeness of recall score for each child was considered. This proportion score consisted of the number of correctly recalled relevant components divided by the total number of components that were relevant for that child. The information pertaining to each event was categorized as a central or peripheral detail and also according to whether it pertained to the injury or hospital event. The data are summed over free and probed recall, with yes–no questions being omitted from the analyses.

Children showed extensive recollection of the events after five years. A repeated-measures ANOVA was calculated with age (five levels) as the between-subjects variable and time (initial versus five years), event (injury versus hospital) and detail (central versus peripheral) as the within-subjects variables. Preliminary overall analyses were completed including gender, but no significant effects were found. Gender was, therefore, excluded from further analyses. Table 1 shows the means for each category according to age. Older children demonstrated better recall of relevant events than younger children, $F(4, 76) = 32.12$, $p < 0.001$. The mean completeness of recall scores for each age group from youngest to oldest were as follows: 37%, 57%, 64%, 72%, and 76%. Paired

Table 1. Mean percentages of the recall completeness scores by age group

	Injury				Hospital			
	Central		Peripheral		Central		Peripheral	
Age in years	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Initial interview								
2	43.67	(21.69)	34.89	(20.78)	29.78	(22.75)	26.33	(14.98)
3–4	72.59	(17.36)	59.12	(17.55)	57.24	(24.27)	44.12	(20.95)
5–6	89.82	(10.07)	70.06	(13.00)	63.65	(18.11)	44.35	(24.29)
8–9	91.95	(9.46)	79.41	(11.26)	73.23	(21.89)	59.41	(24.23)
12–13	90.25	(11.80)	78.31	(14.68)	90.75	(14.54)	64.44	(27.14)
Mean	77.65	(20.56)	64.35	(18.36)	62.93	(22.42)	47.73	(14.98)
Five-year interview								
2	57.22	(16.12)	51.22	(20.38)	29.33	(15.60)	24.56	(19.98)
3–4	79.71	(13.29)	55.59	(19.38)	53.65	(28.14)	32.41	(16.58)
5–6	84.24	(15.81)	65.47	(21.60)	55.18	(24.16)	38.41	(20.57)
8–9	84.59	(10.73)	68.27	(16.06)	73.59	(22.12)	44.09	(22.87)
12–13	81.75	(16.44)	72.75	(17.03)	79.88	(14.70)	47.06	(16.14)
Mean	77.50	(11.51)	62.66	(8.97)	58.32	(19.81)	37.30	(9.06)

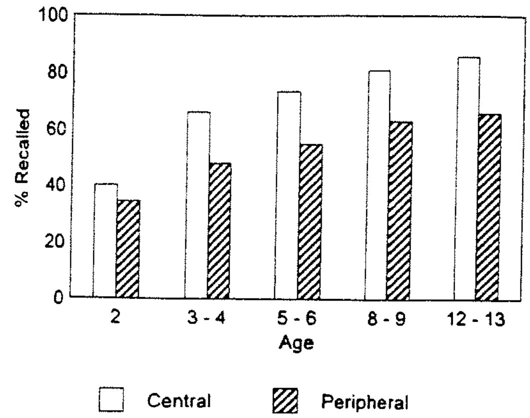

Figure 1. Age × Detail interaction for the completeness of recall scores

comparisons revealed that differences in completeness scores were significant ($p < 0.05$) between all age groups except the two oldest.

Type of detail was found to have a significant effect on percentage recalled, $F(1, 76) = 178.14$, $p < 0.001$, with central events ($M = 72.5\%$) being better remembered than peripheral events ($M = 55.3\%$). Both of these main effects were complicated by an Age × Detail interaction, $F(4, 76) = 3.17$, $p = 0.018$, which is depicted in Figure 1. Analyses of simple effects looked at the effect of detail for each age group separately and found the differences in recall by detail to be significant ($p < 0.001$) for all age groups except for the children who were 2 years of age at the time of injury. Thus, the youngest children recalled both central and peripheral detail similarly, whereas older children recalled central details significantly better.

Children were also more accurate in recalling information pertaining to their injury ($M = 73.4\%$) than their hospital treatment ($M = 54.4\%$), $F(1, 76) = 134.82$, $p < 0.001$. In addition, there was an Age × Event interaction, $F(4, 76) = 2.95$, $p = 0.025$. This interaction is represented in Figure 2. Follow- up analyses compared pairs of age groups

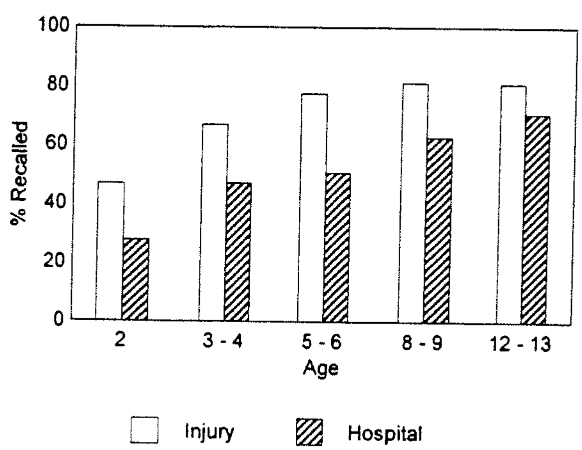

Figure 2. Age × Event interaction for the completeness of recall scores

separately for the injury event and the hospital event. For the injury event, significant ($p < 0.05$) differences were found only among the youngest age groups; age 2 compared with age 3–4, and age 3–4 compared with age 5–6. Children as young as 5 had the same completeness of recall for the injury event as did the oldest children in the study. In comparison, recall for the hospital event found significant ($p < 0.05$) differences between those age 2 compared with those age 3–4, and also those age 5–6 compared with age 8–9. The difference between the two oldest age groups closely approached significance ($p = 0.079$). Thus, completeness of recall shows little variation after age 5 for the injury event, with 5-year-olds recalling as much as 13-year-olds, whereas there is continued improvement with age in the recall of the hospital event.

Also, as predicted children showed a decrease in memory over time, $F(1, 76) = 5.53$, $p = 0.021$. The Age × Time interaction for completeness scores reached only borderline significance ($p = 0.077$). There was also an interaction between time and type of event, $F(1, 76) = 5.35$, $p = 0.023$, which is represented in Figure 3. Analyses of simple effects were completed holding type of event constant and considering effects of time. The effect of time was only found significant ($p = 0.005$) for the hospital event.

In summary, when one considers the completeness of children's recall of prototype components, children demonstrate good recollection of their experiences. As expected, older children show better recall than younger children, and all ages of children are recalling central detail better than peripheral detail and the injury event better than the hospital event, with even those age 2 closely approaching significance. Perhaps most surprising, over the five-year time span only recall for the hospital event showed a significant decrease in memory, while time seemed to have very little effect on the ability to recall details about the injury experience.

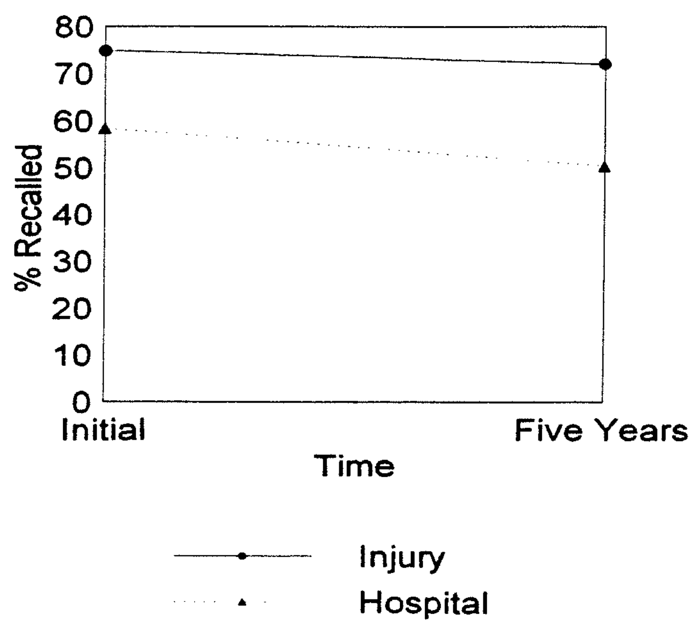

Figure 3. Time × Event interaction for the completeness of recall scores

Table 2. Mean percentages of the accuracy of recalled information by age group

	Injury				Hospital			
	Central		Peripheral		Central		Peripheral	
Age in years	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Initial interview								
2	74.22	(23.23)	93.56	(12.94)	80.56	(34.86)	83.89	(23.09)
3–4	95.18	(7.85)	92.12	(14.01)	94.41	(13.68)	89.00	(14.50)
5–6	97.47	(5.70)	97.06	(8.77)	96.47	(10.57)	94.00	(9.14)
8–9	97.27	(4.87)	98.81	(5.46)	100.00	(0.00)	98.18	(4.79)
12–13	98.44	(6.25)	94.44	(13.73)	96.06	(9.45)	98.63	(3.91)
Mean	92.51	(10.29)	95.19	(2.70)	93.50	(7.51)	92.74	(6.28)
Five-year interview								
2	73.89	(23.88)	71.33	(27.90)	65.00	(32.98)	53.29	(35.57)
3–4	80.65	(12.59)	68.88	(26.32)	68.18	(31.29)	65.29	(24.44)
5–6	86.41	(11.81)	85.47	(16.00)	74.94	(28.32)	67.47	(30.92)
8–9	89.86	(9.96)	89.68	(12.62)	87.64	(21.52)	78.57	(22.73)
12–13	91.44	(13.77)	93.50	(10.43)	89.56	(11.18)	85.25	(17.96)
Mean	84.45	(7.20)	81.77	(11.05)	77.06	(11.14)	69.97	(12.38)

Analyses of accuracy

The same analysis was repeated on the children's second set of scores which represented the accuracy of their responses. The accuracy score was calculated by dividing the number of correct details of information by the total number of details given by the child. Again, gender was included in a preliminary analysis, but was omitted due to its non-significant effect. Table 2 shows the means for each category by age group.

Older children were more accurate in their responses than younger children, $F(4, 72) = 12.66, p < 0.001$. The mean accuracy scores for each age group from youngest to oldest were as follows: 74%, 82%, 87%, 93%, and 93%. Paired comparisons found that differences in accuracy scores reached only borderline significance between 2-year-olds and 3–4-year-olds ($p = 0.070$), and also between 3–4-year-olds and 5–6-year-olds ($p = 0.057$). However, 2-year-olds were significantly ($p < 0.05$) different from 5–6-year-olds. In turn, 5–6-year-olds were significantly less accurate ($ps < 0.05$) than children in both of the older age groups, which did not differ.

Time also influenced the accuracy of recall, $F(1, 72) = 84.60, p < 0.001$, with better recall at the initial assessment ($M = 94.8\%$) than at the five-year assessment ($M = 80.0\%$). These main effects are complicated by an Age × Time interaction, $F(4, 72) = 2.88$, $p = 0.029$, which is depicted in Figure 4. Follow-up analyses compared pairs of age groups separately for the initial interview and for the five-year interview. For the initial interview, those who were age 2 differed significantly ($p < 0.05$) from those who were age 3–4 in their degree of accuracy. Comparisons between all older age groups found no significant difference in accuracy of recall. For the five-year interview the comparisons of each age group with the adjacent age group found no significant differences; however, comparisons between non-adjacent age groups resulted in significant findings. Comparison

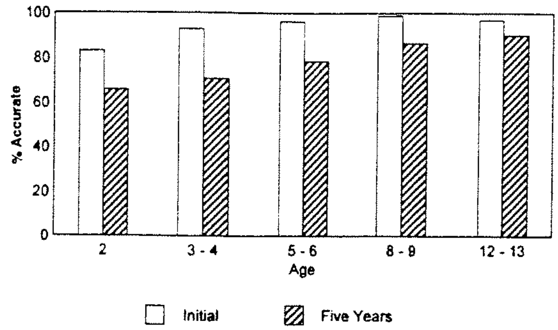

Figure 4. Age × Time interaction for the percentage of recalled details that are accurate

of the 2-year-olds with the 5–6-year-olds closely approached significance ($p = 0.056$), while comparison with the 8–9-year-olds was clearly significant ($p < 0.001$). Comparison between the 3–4-year-olds and the 8–9-year-olds was significant ($p = 0.001$), as was the comparison between the 5–6-year-olds and the 12–13-year-olds ($p = 0.012$). Overall, children are highly accurate in their recollections during the initial assessment with only the 2-year-olds being significantly different from the other age groups. In regard to the five-year assessment, it seems the difference between the age groups follows more of an incremental pattern showing an increase in accuracy with age.

There was also an effect of event, with the injury event ($M = 89.3\%$) being better recalled than the hospital event ($M = 85.4\%$), $F(1, 72) = 3.97$, $p = 0.050$. There was an interaction between time and event, $F(1, 72) = 21.35$, $p < 0.001$, as shown in Figure 5. Analyses of simple effects were performed holding time constant and considering the effect of event. Only at five years was there a significant ($p < 0.001$) difference between accuracy of the injury and hospital events. Although there was no main effect for type of detail, it did interact with time, $F(1, 72) = 6.83$, $p = 0.011$, which is represented in Figure 6. Analyses of simple effects were performed holding time constant and

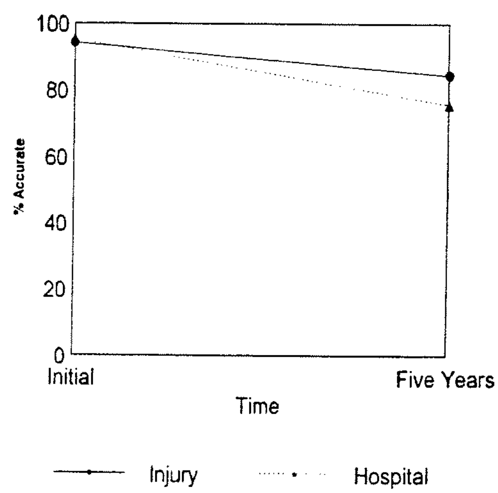

Figure 5. Time × Event interaction for the percentage of recalled details that are accurate

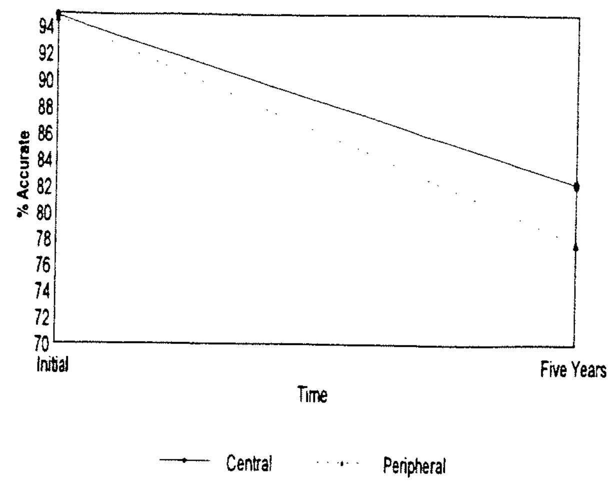

Figure 6. Time × Detail interaction for the percentage of recalled details that are accurate

considering the type of detail. It was only at five years that central details were recalled significantly ($p < 0.05$) more accurately than peripheral details.

In summary, time was important in the accuracy of the children's responses but not in a straightforward manner. Each age group showed less accuracy over time, but more importantly it was mostly the hospital and peripheral recall that suffered. Generally, central details and information pertaining to the injury event were recalled as accurately at five years as they were at the initial assessment.

Analyses of stress effects

Table 3 contains the average stress scores for each age group. The children were given a stress rating for both the time of injury and the time of hospital treatment. Because there was a relationship between stress rating and age, partial correlations were calculated with the effects of age partialled out. There were no significant partial correlations between stress level and children's recall of the injury event, whereas there were two correlations between stress and recall of hospital central details. The more stressed the child, the more likely he or she was to have more complete recall of hospital central details (partial

Table 3. Mean stress scores by age group*

	Injury stress		Hospital stress	
Age in years	*M*	(*SD*)	*M*	(*SD*)
2	5.50	(0.76)	5.17	(1.17)
3–4	3.75	(1.91)	3.87	(1.68)
5–6	4.13	(1.71)	3.69	(2.15)
8–9	3.45	(1.37)	3.23	(1.97)
12–13	3.31	(1.30)	3.07	(1.58)

*Stress scores ranged from 1 = 'not upset, not distressed at all' to 6 = 'extremely upset, highly distressed'.

$r = 0.23$, $p = 0.049$) as well as more accurate recall of hospital central details (partial $r = 0.23$, $p = 0.049$). Stress ratings had no effect on recall of hospital peripheral details. Overall, stress ratings (controlling for age) were unrelated to the completeness or accuracy of recall of the injury event five years later, although there was a relationship with recall of hospital central details.

DISCUSSION

The most striking finding is how well children recalled some aspects of the target event so many years later. Unlike most other research that interviewed children after the passage of a number of years (e.g. Gold and Neisser, 1980; Hudson and Fivush, 1991; Pillemer *et al.*, 1994) children showed remarkable recall of some aspects of the earlier events, especially of the details of their injury. Even after five years, children who were at least 3 years of age recalled over 80% of injury central components, with accuracy rates of over 80%. Recall of peripheral components of their injury was never as complete, but nevertheless what children did recall they recalled with high accuracy.

Considering the 2-year-olds, it is notable that they recalled over half of the components of their injury. Although there was a lot that they did not remember, what they did recall was recalled with considerable accuracy. Over 70% of the details they recalled were correct. These accuracy rates are not derived from responses of 'yes' or 'no', where the likelihood of being correct is 50% by chance alone. Rather, these are content responses to questions such as 'where were you, what happened, who was the first person who reached you after you were hurt?' Thus, chance responding would result in quite low accuracy rates. The former 2-year-olds, who are now age 7, still have considerable recollection of the injuries they had suffered all those years ago. Interestingly, they have even more complete recollection (in terms of the number of components they recall) 5 years later than they did initially. We attribute this not to the children's memory getting better but to the fact that 2-year-olds are notoriously difficult to interview. It is very hard to keep the attention of 2-year-olds during a long interview, even when there are lots of breaks for play, and children this young are often not as cooperative as research subjects as older children.

In comparison to their recall of injury components, 2-year-olds recalled considerably fewer of the components of their hospital treatment. In fact, they never recalled more than a quarter of them, even during their first interview. However, what they did recall was more likely to be correct than incorrect, although they made many mistakes. So, the content of the event they were recalling made a huge difference to them in terms of how memorable it was—as indeed it did with all the children except perhaps the very oldest.

Why do these 2-year-olds still recall their experiences (specifically their injury) so well? Their recall does not fit most predictions of infantile amnesia. One reason may be that not enough time has passed. That is, although they recall these experiences now, they are still only 7 years old. Perhaps these events will fade from memory with the passage of additional years. Another reason may be that all of the prior interviews have made these memories robust. Rehearsal is well-known to help memory (see reviews in Fivush *et al.*, in press. Fivush and Schwarzmueller, 1995; Pool and White, 1995), and in fact an extra rehearsal between 6 months and 2 years was shown to help children's recall of items that were less memorable (Peterson, 1999). In that study, an extra interview helped children recall hospital details, although recall of injury details was still just as high regardless of the number of interviews. In addition, parents probably mentioned the target events from time to time, and such reminders would have reinforced recall. Indeed, amount of subsequent discussion has been shown to affect long-term recall (Goodman *et al.*, 1994). However, such reminders did not seem to have aided children's recall of hospital components. Nor did it help the recall of children who were under 2 at the time of injury (Peterson and Rideout, 1998). Former 1-year-olds were also interviewed again after 5 years had passed (Peddle, 1999), and they recalled virtually nothing of their prior experiences. Their interviews were in striking contrast to those of former 2-year-olds.

Another reason why the recall of former 2-year-olds in this study does not fit with most predictions of infantile amnesia may have to do with the events themselves. Interviews of adults about early experiences find an occasional person who recalls something that happened when he or she was as young as 2 years of age (McCabe *et al.*, 1991; Mullen, 1994). These events tend to be highly emotional and salient as well as distinct, and it has been suggested that highly emotional events in particular are more likely to be retained (Quas *et al.*, 1999). It may simply be that the injuries suffered by these children fit the pattern of events that retain memorability over long periods of time. Certainly the children were extremely distressed at the time of their injuries. Their parental ratings of distress averaged 5.5 with the maximum rating equal to 6. Parents described their children at the time of their injury as being extremely upset, and usually 'hysterical' was the term used. But distress alone is probably not enough. After all, most of the 2-year-olds were just as distressed at the time of hospital treatment and yet only random pieces of this event were recalled. Thus, we suggest that the event has to not only be emotional but also comprehensible and coherent for it to be retained long-term. In the child's view, many of the events that occurred at the hospital may not have had temporal, enabling, or causal coherence. In the hospital, children were taken to a waiting room, then into a room where vital signs were taken by someone, then back to the waiting room for a wait that at times was quite long, then to another room for another person (or several) to see them, then often to another part of the hospital (e.g. for X-rays), and back again, and so on. That is, the rather arbitrary ordering (in the child's view) of various hospital events, in contrast to the causally and temporally coherent nature of the sequential events during the injury episode, may have been responsible for children's worse recall of the treatment than injury. In support of this interpretation, researchers (Bauer, 1992; Bauer and Mandler, 1989) have found that very young children have better recall of causally related sequences than of arbitrarily related sequences.

The long-term retention of events that had occurred when they were 2 years old by children in this study supports suggestions that there is no sudden off-set of infantile amnesia. Usher and Neisser (1993) argue, on the basis of their data on college students' memory for four major life events, that the dating of infantile amnesia is partly a function of content. In their study, hospitalizations and sibling births dating from age 2 were likely to be recalled whereas the earliest recall of deaths and family moves dated from 3 or 4 years of age. A number of investigators have argued against a major shift in memory processes over this time period, and that continuity rather than discontinuity characterizes memory processes (e.g. Bauer and Wewerka, 1995; Howe and Courage, 1997). Thus, children's event memory skills may gradually change, leading to an increasing probability with age that salient events are retained in memory over the long term. Our findings suggest that a number of variables may affect timing for the off-set of infantile amnesia, and that some events from very early ages may persist in autobiographical memory while most do not.

Returning to a comparison of children's memory for injury versus hospital events, as children get older the things that happen at the hospital may become more understandable or coherent. This increasing coherence in turn may contribute to hospital events becoming more memorable with age. The oldest children recalled hospital events as well as injury events, and in particular there was a substantial increase in children's recall of hospital central events between 6 and 8 years of age—a period of considerable cognitive growth.

This study supports prior research that has emphasized differences between central and peripheral details (Christianson, 1992). Detail centrality (defined as plot relevance) contributed to children being more likely to recall it. Although peripheral details were less likely to be remembered at all, those that were recalled were often remembered with as much accuracy as central details, especially by older children.

The stress levels of children had little effect on their recall of injury details, at least when age was controlled for. None of the partial correlations were significant for recall of the injury. This may be because this episode was so well recalled anyway, i.e. there was a ceiling effect. However, higher stress levels did facilitate recall of hospital central events. That is, children who were more highly distressed tended to have better recall five years later of the central treatment components, and in particular what the doctor did to them. But age-controlled stress ratings were unrelated to recall of peripheral details. This fits with suggestions that high stress levels are more likely to focus attention on central, key details (Christianson, 1992). Thus, the effects of stress were modest, but high stress levels did seem to facilitate children's recall of the episode that was more difficult for them to remember, namely hospital treatment, while at the same time it had no effect on their recall of the episode that was highly memorable anyway, namely the injury.

These findings have implications for children's eyewitness testimony. Most importantly, children who are reminded of their experiences can recall them with considerable completeness and accuracy five years later. Of course, there are limitations to this assertion. First, these children were never misled during any of the interviews. Second, they were regularly reminded of the target events, particularly during the first year after they occurred. It is unclear how well they might have recalled these events if there had been no interim reminders. Quas *et al.* (1999) found that children who had not had these earlier interviews still remembered a lot about the VCUG, at least if they were over 4 years of age, but not many in their sample had delays as long as 5 years between event occurrence and recall opportunity. Third, these events were not embarrassing or the sorts of experiences that children would try to avoid talking about, which might decrease the amount reported (Quas *et al.*, 1999; Steward *et al.*, 1996). Fourth, the nature of the event made a difference. Although children had experienced both an injury and subsequent hospital treatment of that injury, only the former was recalled with any completeness or clarity.

Despite these caveats, this study suggests that if events are coherent and sensible to the child, even if they are very distressing, children's recall of them can be remarkably good. This is especially the case for main or central components. Although the recall of children who had been only 2-year-olds at the time of event occurrence had completeness and accuracy rates that might be problematic in a forensic situation, children as young as 3 or 4 at the time of event occurrence had impressive recall. Nor did high stress levels cause children's recall to suffer. Rather, it seemed to facilitate children's recall of items that seemed to be inherently harder to recall. This study did not look at individual differences between children that may have facilitated or hindered their recall, and clearly this also is an important avenue to explore. Nevertheless, children showed considerable ability to recall events even after a delay of five years.

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REFERENCES

Baker-Ward L, Burgwyn E, Ornstein PA, Gordon B. 1995. Children's reports of a minor medical emergency procedure. In *Children's Memory for Emotional and Traumatic Events*, Goodman G, Baker-Ward L(Chairs). Symposium conducted at the Society for Research in Child Development, April, Indianapolis, IN.

Bauer P. 1992. Holding it all together: how enabling relations facilitate young children's event recall. *Child Development* **7**: 1–28.

Bauer PJ, Mandler JM. 1989. One thing follows another: effects of temporal structure on 1- to 2-year-olds' recall of events. *Developmental Psychology* **25**: 197–206.

Bauer PJ, Wewerka SS. 1995. One- to two-year-olds' recall of events: the more expressed, the more impressed. *Journal of Experimental Child Psychology* **59**: 475–496.

Bruck M, Ceci SJ, Francoeur E, Barr R. 1995. 'I hardly cried when I got my shot!' Influencing children's reports about a visit to their pediatrician. *Child Development* **66**: 193–208.

Burgwyn-Bailes E, Baker-Ward L, Gordon BN, Ornstein PA. 2001. Children's memory for emergency medical treatment after one year: the impact of individual difference variables on recall and suggestibility. *Applied Cognitive Psychology* **15**: S25–S48.

Christianson S-A. 1992. Emotional stress and eyewitness memory: a critical review. *Psychological Bulletin* **112**: 284–309.

Eisen ML, Goodman GS, Qin J, Davis SL. 1998. Memory and suggestibility in maltreated children: new research relevant to evaluating allegations of abuse. In *Truth in Memory*, Lynn S (ed.). Guilford: New York; 163–189.

Fay WH. 1975. Occurrence of children's echoic responses according to interlocutory question types. *Journal of Speech and Hearing Research* **18**: 336–345.

Fivush R, Gray JT, Fromhoff FA. 1987. Two-year-olds talk about the past. *Cognitive Development* **2**: 393–409.

Fivush R, Haden C, Adam S. 1995. Structure and coherence of preschoolers' personal narratives over time: implications for childhood amnesia. *Journal of Experimental Child Psychology* **60**: 32–56.

Fivush R, Peterson C, Schwarzmueller A. in press. Questions and answers: the credibility of child witnesses in the context of specific questioning techniques. In *Memory and Suggestibility in the Forensic Interview*, Eisen ML, Goodman GS, Quas JA (eds). Erlbaum: Hillsdale, NJ.

Fivush R, Schwarzmueller A. 1995. Say it once again: effects of repeated questions on children's event recall. *Journal of Traumatic Stress* **8**: 555–580.

Gold E, Neisser U. 1980. Recollections of kindergarten. *Quarterly Newsletter of the Laboratory of Comparative Human Cognition* **2**: 77–80.

Goodman GS, Hirschman JE, Hepps D, Rudy L. 1991. Children's memory for stressful events. *Merrill-Palmer Quarterly* **37**: 109–158.

Goodman GS, Quas JA, Batterman-Faunce JM, Riddlesberger MM, Kuhn J. 1994. Predictors of accurate and inaccurate memories of traumatic events experienced in childhood. *Consciousness and cognition* **3**: 269–294.

Goodman GS, Quas JA, Batterman-Faunce JM, Riddlesberger MM, Kuhn J. 1997. Children's reactions to and memory for a stressful event: influences of age, anatomical dolls, knowledge, and parental attachment. *Applied Developmental Science* **1**: 54–75.

Gray E. 1993. *Unequal Justice: The Prosecution of Child Sexual Abuse.* Free Press: New York.
Hamond NR, Fivush R. 1991. Memories of Mickey Mouse: young children recount their trip to Disneyworld. *Cognitive Development* **6**: 433–448.
Heuer F, Reisberg D. 1992. Emotion, arousal and memory for detail. In *Handbook of Emotion and Memory*, Christianson SA (ed.). Erlbaum: Hillsdale, NJ; 151–180.
Howe ML. 1997. Children's memory for traumatic experiences. *Learning and Individual Differences* **9**: 153–174.
Howe ML, Courage ML. 1997. The emergence and early development of autobiographical memory. *Psychological Review* **104**: 499–523.
Hudson JA, Fivush R. 1991. As time goes by: sixth graders remember a kindergarten experience. *Applied Cognitive Psychology* **5**: 347–360.
McCabe A, Capron E, Peterson C. 1991. The voice of experience: the recall of early childhood and adolescent memories by young adults. In *Developing Narrative Structure* McCabe A, Peterson C. (eds). Erlbaum: Hillsdale, NJ; 137–173.
Merritt KA, Ornstein PA, Spicker B. 1994. Children's memory for a salient medical procedure: implications for testimony. *Pediatrics* **94**: 17–23.
Mullen MK. 1994. Earliest recollections of childhood: a demographic analysis. *Cognition* **52**: 55–79.
Peddle M. 1999. *Implicit Memory for Medical Emergencies Experienced by 1 Year Olds.* Unpublished thesis, Memorial University of Newfoundland.
Peterson C. 1999. Children's memory for medical emergencies: two years later. *Developmental Psychology* **35**: 1493–1506.
Peterson C, Bell M. 1996. Children's memory for traumatic injury. *Child Development* **67**: 3045–3070.
Peterson C, Biggs M. 1997. Interviewing children about trauma: problems with 'specific' questions. *Journal of Traumatic Stress* **10**: 279–290.
Peterson C, Dowden C, Tobin J. 1999. Interviewing preschoolers: comparisons of yes/no and wh-questions. *Journal of Law & Human Behavior* **23**: 539–556.
Peterson C, Rideout R. 1998. Memory for medical emergencies experienced by one and two year olds. *Developmental Psychology* **34**: 1059–1072.
Pillemer DB. 1992. Preschool children's memories of personal circumstances: the fire alarm study. In *Affect and Accuracy in Recall: Studies of 'Flashbulb' Memories*, Winograd E, Neisser U (eds). Cambridge University Press: New York; 121–137.
Pillemer DB, Picariello ML, Pruett JC. 1994. Very long term memories of a salient preschool event. *Journal of Applied Cognitive Psychology* **8**: 95–106.
Pillemer DB, White SH. 1989. Childhood events recalled by children and adults. *Advances in Child Development and Behavior* **21**: 297–340.
Poole DA, White LT. 1995. Tell me again and again: stability and change in the repeated testimonies of children and adults. In *Memory and Testimony in the Child Witness*, Zaragoza MS, Graham JR, Hall GCN, Hirschman R, Ben-Porath YS (eds). Sage: Thousand Oaks, CA; 24–43.
Quas JA, Goodman GS, Bidrose S, Pipe M-E, Craw S, Ablin DS. 1999. Emotion and memory: children's long-term remembering, forgetting, and suggestibility. *Journal of Experimental Child Psychology* **72**: 235–270.
Rapaport D. 1942. *Emotions and Memory*. Menninger Clinic Monograph Series, No. 2. Wiley: New York.
Sheingold K, Tenney YJ. 1982. Memory for a salient childhood event. In *Memory Observed*, Neisser U (ed.). Freeman: San Francisco; 201–212.
Steward MS, Steward DS, Farquhar L, Myers JEB, Reinhart M, Welker J, Joye N, Driskill J, Morgan J. 1996. Interviewing young children about body touch and handling. *Monographs of the Society for Research in Child Development 57* (4–5, Serial No. 248).
Terr L. 1988. What happens to early memories of trauma? A study of twenty children under age five at the time of documented traumatic events. *Journal of American Academic Child and Adolescent Psychiatry* **27**: 96–104.
Usher JA, Neisser U. 1993. Childhood amnesia and the beginnings of memory for four early life events. *Journal of Experimental Psychology: General* **122**: 155–165.
Vandermaas MO, Hess TM, Baker-Ward L. 1993. Does anxiety affect children's reports of memory for a stressful event? *Journal of Applied Psychology* **7**: 109–128.

APPENDIX: PROTOTYPE OF INJURY AND HOSPITAL TREATMENT WITH EXAMPLES OF ITEMS AND CLASSIFICATION CATEGORY AS CENTRAL-INSIDE (C), PERIPHERAL-INSIDE (P-IN), OR PERIPHERAL-OUTSIDE (P-OUT) DETAIL

Item	Example	Category
	THE INJURY	
Time of day	'*Right after lunch*'	P
Place	'In my *backyard*'	P
Who was with you	'*Mom* and my *brother* Joe'	P
Who else was around	'My *friend Anna* was playing there too'	P
Actions prior to injury	'I was *running*'	P
What happened	'I got a big *cut* on my leg'	C
How it occurred	'I was *tripped*'	C
Who did it	'By my *brother*'	C
What objects involved	'I hit a *piece of the porch* that was sticking up'	C
Cry	'I had to just *scream*'	C
Blood	'It was *bleeding* all down my leg'	C
Who first responded	'*Mommy* heard me cry'	C
Where you went before hosp.	'She took me into the *kitchen*'	P
Actions to treat injury	'She *wiped* my knee'	C
Objects of home treatment	'And put a *cloth* on my knee to soak up blood'	C
Anyone else look/help?	'My *brother* was watching'	P
Went to hospital	'Then I went to the *hospital*'	C
Who took you to hospital	'*Mom* drove me there'	P
Who else went along	'My *brother* had to come too'	P
Time of hospital trip	'We got to the hospital *half an hour later*'	P
	THE HOSPITAL TREATMENT	
Registration	'A nurse *checked me in*'	P
Vitals measured	'I got my *blood pressure* taken'	P
Waiting period	'I had to *wait a long time*'	P
Actions while waiting	'I *watched the TV*'	P
Initial exam	'Finally somebody *looked at my cut*'	C
Hospital personnel	'It was a *girl doctor*'	C
X-rays	'I got an *X-ray* because they thought something was still in my knee'	C
Cast	(not relevant)	C
Needles	'I got 4 *needles* to put my knee asleep'	C
Stitches	'And then I got 14 *stitches*'	C
Bandage	'I got a big *bandage* all down my leg'	C
Sheet	'They wrapped me in a big *sheet*'	C
Procedural details	'The doctor *washed out my cut* first'	P
Other treatment objects	'With *soap*'	P
Cry	'That made me *cry*'	C
Popsicle	'The nurse gave me a *yellow popsicle*'	P
Family in treatment room	'My *Mom* was in there with me'	P

